GRASSROOTS JOURNALS

Grassroots Journal of Natural Resources, Vol.8 No.2 (August 2025)
ISSN: 2581-6853 | CODEN: GJNRA9 | Published by The Grassroots Institute
Website: https://grassrootsjournals.org/gjnr | Main Indexing: Scopus and WoS

ISSN 2581-6853 | 8(2) August 2025

00570 | Analytical Article

Effectiveness of Carbon Tax with the Carbon Market to respond to Vietnam's Global Climate Change

Phan Phuong Nam*[1], Pham Huy Hoang[2], Nguyen Xuan Bang[3]
[1]Faculty of Commercial Law, Ho Chi Minh City University of Law, Ho Chi Minh City, Vietnam.
Email: phanphuongnam@gmail.com | ORCID: https://orcid.org/0009-0009-6293-0899
[2]Faculty of Economic Law, Ho Chi Minh City University of Law, Ho Chi Minh City, Vietnam.
Email: phamhuyhoang090913@gmail.com | ORCID: https://orcid.org/0009-0005-7076-6604
[3]Faculty of Law, Hutech University, Ho Chi Minh City, Vietnam.
Email: nguyenxuanbangdalat1979@gmail.com | ORCID: https://orcid.org/0009-0006-0205-2367
Corresponding author

How to cite this paper: Nam, P.P., Hoang, P.H. and Bang, N.X. (2025). Effectiveness of Carbon Tax with the Carbon Market to respond to Vietnam's Global Climate Change. *Grassroots Journal of Natural Resources*, 8(2): 448-466. Doi: https://doi.org/10.33002/nr2581.6853.080221

Received: 03 July 2025
Reviewed: 21 July 2025
Provisionally Accepted: 25 July 2025
Revised: 29 July 2025
Finally Accepted: 14 August 2025
Published: 25 August 2025
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Abstract

Vietnam is actively addressing climate change, aiming to achieve net-zero emissions by 2050. A carbon market has already been established in compliance with Decree No. 06/2022/ND-CP and the Law on Environmental Protection of 2020, with operations anticipated to begin in 2028 or 2029. However, the current legal system does not specifically address carbon taxation. Nevertheless, a carbon tax is a financial tool that would help Vietnam meet its obligations abroad, including those outlined in the 2015 Paris Agreement. To date, while Vietnam may have achieved certain successes in addressing climate change, the current legal provisions still present challenges concerning the pricing mechanism, the monitoring, reporting, and verification (MRV) system, and the exchange of information across sectors. Adding a carbon tax to the Law on Environmental Protection Tax of 2010 and making the rules about who has to pay taxes and how much clearer could help solve these problems. Additionally, to set a fair tax rate and a strong MRV system, there needs to be better coordination between sectors, more support for small and medium-sized businesses, and the use of best practices from other countries. Vietnam wants to have net-zero emissions by 2050, and the carbon market and a carbon tax working together would make that goal easier to reach. This method would also provide Vietnam a stronger voice in climate talks around the world.

Keywords

Carbon market; Carbon tax; Net Zero 2050; Legal framework; Climate change

Introduction

Climate change is posing serious challenges for Viet Nam, one of the most vulnerable countries to phenomena such as sea level rise, storms and floods, and rising temperatures (IPCC, 2022; Shob and

Joshi, 2022). As a member of the 2015 Paris Agreement and with the commitment to achieve the goal of Net Zero by 2050 announced at COP26 (2021), Vietnam has affirmed its determination to respond to global climate change through legal and economic policies (UNFCCC, 2020). To put carbon markets and taxes into place, we need a strong legal framework. This will help cut greenhouse gas emissions and move us towards a green economy. The current legal framework does set the stage for a carbon market, but it doesn't have any specific rules about carbon taxes. This makes it harder to put a price on carbon and reach international climate goals (Nguyet, 2025).

Carbon credits are permits that can be passed on to someone else and let them release one tonne of carbon dioxide (CO2) or an equivalent amount of other greenhouse gases (Salma, Fryda and Djelal, 2024; Sorensen, 2023; Tsai, 2020). Carbon markets, also called emissions trading systems (ETS), are market-based systems that set a limit on the total amount of greenhouse gases that can be emitted and let people trade these permits (Zhijie and Lin, 2020). This idea is closely related to them. These are two main ways to price carbon, along with carbon taxes. They are meant to give carbon a cost and encourage people to cut back on emissions (Timilsina, 2022;).

What carbon credits do. Carbon credits and carbon markets have many different jobs to do, both at home and around the world. They are also important climate-leverage tools that give industries and countries economic reasons to look for cleaner technologies (Green, 2021; O'Mahony, 2020). These markets also encourage innovation and facilitate emission reductions (Dobrovolska *et al*., 2024; Gurtu, Vyas and Gurtu, 2022; Kovalenko *et al*., 2023) in the most cost-effective ways, which leads to better resource use (Goulder and Schein, 2013). They also encourage climate action across borders by allowing people to trade credits to meet emissions goals (Timilsina, 2022; Thisted and Thisted, 2019).

Vietnam is greatly affected by carbon credits and carbon markets. The Law on Environmental Protection 2020 and Decree 06/2022/ND-CP set up the carbon market in Vietnam. Emission quotas will be given out starting in 2025, and the market will officially open in 2028-2029 (Government of Vietnam, 2022). Companies can buy and sell carbon credits and quotas, which gives them financial reasons to cut back on their emissions. As a result, the adoption of such mechanisms can support Vietnam in realizing international commitments in reducing emissions (Jaelani *et al*., 2024). They serve to promote green investment and to draw financial resources into low-carbon technologies and industries at home, helping achieve the growth of green investment and sustainable economic growth (Ikhtiari, Nurfadila and Ibrahim, 2024). At the same time, a carbon market at home will support Vietnamese enterprises in the process of competing in international trade (Ramadhani and Koo, 2022). In the end, either the auctioning of carbon credits or revenue collected from carbon taxes can also provide valuable financial benefits to the Vietnamese government to be used in investments to adapt to and mitigate climate change or compensate potential distributional impacts.

From the perspective of economic law, merging the carbon tax with the existing legal framework entails the articulation of tax norms, environmental administration, and emissions control. As of now, the Law on Environmental Protection Tax 2010 fails to explicitly stipulate a carbon tax, resulting in the internalization of environmental costs and on carbon market being insufficient (Ngan, 2023). Accordingly, it is essential to

establish a holistic legal system that coordinates carbon taxes and carbon trade to play the role of responding effectively to global climate change. This study aims to analyze the current legal framework of the carbon market in Vietnam, assess the possibility of integrating carbon taxes as an add-on tool, and propose legal solutions to optimize the relationship between these two tools in responding to global climate change.

Specifically, the study will: (1) find legal gaps in the current rules about carbon markets and environmental taxes; (2) look at how carbon taxes and carbon markets are related legally, based on what has happened in other countries; and (3) suggest a unified legal framework to help Vietnam reach Net Zero by 2050. The legal suggestions will be based on the ideas of openness, fairness, and practicality, and they will also take into account how they will affect Vietnam's economy and society (Aldy and Stavins, 2012).

Analysis and Discussion

Current legal framework of the carbon market in Vietnam

The Law on Environmental Protection, which was passed in 2020, is the main law in Vietnam that makes the carbon market work. This paper has helped a lot with making tools that can help stop climate change. This law's Article 139 tells you how to start and run carbon markets. There will be a list of greenhouse gases, a list of emission quotas, and a way to trade carbon credits in these markets (National Assembly of Vietnam, 2020). Then, the Vietnamese government made the plan for the carbon market more concrete by issuing Decree 06/2022/ND-CP (Regulations on Greenhouse Gas Emission Mitigation and Ozone Layer Protection). The plan is to start giving out emission quotas in 2025 and officially start working in 2028–2029 (Government of Vietnam, 2022). Vietnam is serious about keeping its promise to meet the 2015 Paris Agreement and the goal of Net Zero by 2050. These rules show that. They also give businesses a legal reason to join the emissions trading system (UNFCCC, 2022).

Vietnam's legal framework for the carbon market has made significant progress. Decree 06/2022/ND-CP has established a clear roadmap, including regulations for greenhouse gas inventories and the allocation of emission quotas to major industries like power, steel, and cement (Government of Vietnam, 2022). In addition, Vietnam has piloted carbon credit projects, such as afforestation and renewable energy programs, which are a key step toward connecting with the international carbon market (World Bank Group, 2022). An emissions monitoring, reporting, and verification (MRV) system is also being developed to ensure transparency and compliance with international standards, particularly for forest carbon credits (Dung, Ngoc and Huy, 2024). These efforts demonstrate Vietnam's commitment to building a legal framework that aligns with both its domestic economic context and international obligations.

Even with these successes, the current legal system still has some problems. One big problem is that there aren't any clear rules about how to price carbon or how to punish people who break the rules (Nguyet, 2025). This makes it harder to put the rules into practice. The MRV system is still being developed and hasn't yet fully met the standards for accuracy and openness, especially for small and medium-sized businesses (Dung, Ngoc and Huy, 2024). Also, the current system doesn't include a carbon tax, which

makes it harder for the carbon market to work well and set a stable price floor for CO2 emissions (Ngan, 2023). Lastly, there isn't enough cooperation between ministries like the Ministry of Natural Resources and Environment, the Ministry of Finance, and the Ministry of Industry and Trade. This could lead to policies that are the same or that don't work well together (OECD, 2021).

The above limitations point to the urgent need to supplement and complete the legal framework to integrate carbon taxes into the current carbon market. Carbon taxes can serve as an add-on tool, helping to establish a floor price for emissions and encourage businesses to transition to green technology (Aldy and Stavins, 2012). However, for the legal framework to work, it must set tax rates, taxable objects, taxpayers, and ways to get out of paying taxes, and it must also work with carbon market rules to make sure they don't overlap (Nguyet, 2025). The completion of the legal framework will help Vietnam meet its international obligations and make its economy more competitive. This is especially important because the EU's Carbon Border Adjustment Mechanism (CBAM) will start in 2026 and will charge carbon prices on high-carbon imports like steel, cement, and electricity (European Commission, 2024)

The issue of integrating the carbon tax into Vietnam's current legal framework

Carbon taxes are an important economic tool to internalize the environmental costs of greenhouse gas emissions, motivating businesses and individuals to adopt technological solutions and sustainable behaviors to reduce emissions (Aldy and Stavins, 2012). In Vietnam, adding a carbon tax to the current laws that govern the carbon market, as described in the Law on Environmental Protection 2020 and Decree 06/2022/ND-CP, is expected to create a stable price floor mechanism. This integration will make the emission quota and carbon credit trading system work better, leading to a stronger and more effective way to manage emissions and fight climate change (Government of Vietnam, 2022). The carbon tax not only helps to price CO2 emissions transparently but also creates a source of state budget revenue to finance climate projects such as renewable energy and forest management... has been emphasized in climate development reports (World Bank Group, 2022). Also, a carbon tax will help Vietnam meet its obligations under the 2015 Paris Agreement and the Net Zero goal by 2050, while also lowering the risks of border carbon tax measures like the EU's Carbon Border Adjustment Mechanism (CBAM) (European Commission, 2024). Countries like the EU and China have shown that carbon pricing tools can lead to climate action by significantly lowering the emissions of businesses through pilot programs in the carbon market (Cui *et al*., 2021).

The integration of carbon tax into Vietnam's legal framework faces many challenges as follows:

Firstly, the current environmental tax system, according to Vietnam's 2010 Environmental Protection Tax Law, mainly focuses on fossil fuels and does not have a comprehensive carbon tax mechanism targeting greenhouse gas emissions from industries (Nguyen, 2023). This makes it hard to set a fair price for emissions because tax policy and carbon market rules don't match up (Goulder and Schein, 2013). Second, as shown in global carbon market studies (OECD, 2021), the Ministry of Finance, the

Ministry of Natural Resources and Environment, and the Ministry of Industry and Trade do not always work together in a coordinated way, which can lead to policies that are the same or that conflict with each other. Third, small and medium-sized enterprises, which account for the majority of Vietnam's economy, often lack the financial and technological resources to comply with carbon tax regulations, especially in areas such as forest carbon credits (Dung, Ngoc and Huy, 2024).

Ultimately, determining the right carbon tax rate is a major challenge. This is because too high a tax rate can increase production costs and affect competitiveness, while a tax that is too low will not be enough to encourage emission reductions, as discussed in comparative studies between carbon taxes and carbon markets (Xu, Wang and Zhang, 2023). To make a carbon tax work in Vietnam's legal system, the country needs to take the following steps:

First, the Law on Environmental Protection Tax 2010 needs to be changed to add rules about the carbon tax, make it clear what things are taxable (like big industries that emit a lot of CO2, like electricity, steel, and cement), and set tax rates based on how much CO2 they emit.To make this happen, Vietnam needs to look at how other countries in the region, like China (Li, Wang and Qin, 2025), run their carbon markets.

Second, we need to form a national committee on carbon tax and carbon markets to make sure that all sectors work together better, that ministries and sectors are on the same page, and that policies don't overlap (Nguyet, 2025). There, this committee will be the person responsible to the state in creating coordination between state agencies so that these regulations are applied effectively.

*Third, to support small and medium-sized enterprises, the government can adopt carbon tax exemption and reduction policies in the early stages, combined with technical and financial assistance programs as proposed in the forest carbon credit studies (*Dung, Ngoc and Huy, 2024*).* On the one hand, this is to support difficulties for small and medium-sized enterprises when the application of these regulations will increase costs and reduce profits for these businesses. From another perspective, tax incentives will have an impact on supporting, encouraging, and attracting investment capital and clean projects, reducing emissions.

Fourth, Vietnam needs to learn from international experience. Vietnam needs to look at Canada's carbon tax model or the EU's carbon market system to make its tax system more open and useful (Calel and Dechezleprêtre, 2016).

Finally, Vietnam needs to improve its monitoring, reporting, and verification (MRV) system so that it can get accurate emissions data. This will help make sure that carbon taxes are calculated and collected fairly. This is very important to show that the tools used are working and to make sure that the right choices are made for Vietnam to fulfil its national commitments to global climate change response (UNFCCC, 2022).

Adding a carbon tax to the rules will have many benefits, but it will also cause some economic problems. The carbon tax will encourage businesses to invest in green technologies, use less fossil fuels, and help the growth of renewable energy industries. This will make Vietnam's economy more competitive in the global market (Bui, 2024). The money made from carbon taxes can be used again for climate projects like protecting forests or making renewable energy, which will help the goal of Net Zero by A carbon tax could, however, make it more expensive for industries that use a lot of carbon, like cement and steel, to make things in the short term. This will change the prices of goods and how competitive Vietnamese goods are, especially when these goods are sold to CBAM markets like the EU (Böhringer, Müller and Schneider, 2015). A carbon tax could, however, make it more expensive for industries that use a lot of carbon, like cement and steel, to make things in the short term (European Commission, n.d.). This will help lessen this effect. Studies on the role of carbon markets in reaching global climate goals (Santos, 2022) show that the carbon tax not only helps Vietnam meet its international obligations, but it also strengthens its position in global climate negotiations and supports a sustainable, low-carbon economy.

International experience in integrating carbon tax into the carbon market

Experience from the EU

The EU Emissions Trading System (EU ETS) was started by the European Union in 2005. It is now the world's largest carbon market, covering about 40% of the EU's greenhouse gas emissions (Ellerman and Buchner, 2007). The EU ETS works on a "cap-and-trade" system, which means that heavy industries like electricity, steel, cement, and intra-bloc aviation have to stay below a certain level of emissions (the cap). These industries are given or auctioned off emission quotas (Calel and Dechezleprêtre, 2016). To meet emission reduction goals, businesses can buy and sell quotas on the market. This gives them economic reasons to use low-carbon technologies (Calel and Dechezleprêtre, 2016). The EU ETS has cut emissions from participating industries by about 35% between 2005 and 2023. It has also encouraged investment in renewable energy and energy-efficient technologies, with little effect on GDP growth (European Commission, 2025). A clear MRV system is a key part of the EU ETS. It requires businesses to report their emissions data every year, which is checked by independent third parties to make sure it is correct and that the rules are being followed (Santos, 2022).

The EU has also set up the Carbon Border Adjustment Mechanism (CBAM) to tax carbon on goods brought in from countries that don't have the same carbon pricing policies. This includes steel, cement, aluminium, and fertilizers (Aldy and Stavins, 2012). The CBAM is meant to stop "carbon leakage," which happens when companies move production to countries with less strict environmental rules. It also protects the competitiveness of EU industries (Böhringer, Müller and Schneider, 2015). Heavy industries are against the EU ETS and CBAM because they think they will cost too much to comply with, and it is hard to find the right carbon price that will balance climate goals with economic growth (Haites, 2018). The EU's experience shows how important it is to have a strict set of rules, a reliable MRV system, and policies that help vulnerable sectors in the early stages, like allowing them to skip quotas, to lessen the economic effects and promote technological progress.

Experience from China

Since 2013, China has run carbon market pilot programs in seven areas, including Beijing, Shanghai, and Shenzhen. In 2021, it launched the National Emissions Trading System (ETS), which focusses on the coal-fired power sector, which is responsible for about 40% of China's total CO2 emissions (Cui *et al*., 2021). The pilot programs have been remarkably successful. In the Guangdong and Shenzhen regions, emissions are identified as decreasing by 15-20% in participating industries thanks to a quota allocation mechanism based on energy efficiency and market transactions (Cui *et al*., 2021). Launched in July 2021, the national ETS has grown to become the largest carbon market globally in terms of emission scale, encompassing over 2,200 power plants with an annual total emission of approximately 4.5 billion tonnes of CO_2 (Transition Asia, 2025). China uses a flexible carbon pricing mechanism, with an initial carbon price of 40–60 CNY/ton of CO2 (roughly 6–9 USD), which is lower than the EU ETS (roughly 80–100 EUR/tonne) to ease the financial burden on startups. (Li, Wang and Qin, 2025).

China is thinking about adding a carbon tax to the ETS to help it reach its goal of being carbon neutral by 2060. This would be especially useful in the coal-fired power sector (Li, Wang and Qin, 2025). Studies show that combining carbon taxes with ETS can make cutting emissions more effective, especially in industries that use a lot of energy. This is because it sets a stable floor price and encourages a shift to cleaner energy sources (Xu, Wang and Zhang, 2023). However, China faces many challenges, including heterogeneous emissions data across regions, a lack of participation by small and medium-sized industries, and difficulties in determining the optimal carbon price to balance emissions reduction and economic growth (Zhang *et al*., 2014). China's MRV system is also limited by the lack of uniform standards and independent oversight, leading to the risk of a lack of transparency in emissions reporting (Zhang *et al*., 2014). To address these challenges, China has stepped up technical training, international cooperation with organizations such as the World Bank and expanded the scope of the ETS to include industries such as steel and cement from 2025, as recorded in recent development plans (World Bank Group, 2022). The experience from China highlights the necessity for a phased implementation roadmap, supportive policies for small businesses, and investments in MRV systems to enhance the effectiveness of carbon pricing mechanisms.

Lessons for Viet Nam

Vietnam can learn a lot from what the EU and China have done to add the carbon tax to the rules for the carbon market. Vietnam needs to make a clear legal framework, change the 2010 Law on Environmental Protection Tax to include a carbon tax, and make sure it works with the carbon market roadmap set out in Decree 06/2022/ND-CP (Government of Vietnam, 2022).

Second, emissions data needs to be accurate and a fair carbon tax needs to be collected. One way to do this is to set up a clear and trustworthy MRV system, like the one used in the EU ETS (World Bank Group, 2022). Third, research on forest carbon credits (Dung, Ngoc and Huy, 2024) says that Vietnam should ask China for help with small and medium-sized businesses, such as tax breaks or technical support. Fourth, Vietnam needs

to make a strong domestic carbon pricing system to get ready for the EU's CBAM. This will make sure that industries that export things like steel and cement can meet international standards (Böhringer, Müller and Schneider, 2015). Finally,Vietnam will be able to work with groups like the World Bank and coordinate efforts across sectors to build a good carbon pricing system, help reach the Net Zero goal by 2050, and improve its standing in global climate talks (Bui, 2024).

Challenges and opportunities

Legal and institutional challenges

The integration of the carbon tax into the regulatory framework of the carbon market in Vietnam faces the following legal and institutional challenges:

First, the current legal framework, including the Law on Environmental Protection Tax in 2010 and Decree 06/2022/ND-CP, does not have specific regulations on carbon tax, leading to a gap between environmental tax policies and the requirements of a comprehensive carbon pricing system (Ngan, 2023). Amending the law to include a carbon tax requires consensus among regulators such as the Ministry of Finance, the Ministry of Natural Resources and Environment, and the Ministry of Industry and Trade, but the lack of interagency coordination can cause policy overlap or conflict, as documented in analyses of global carbon pricing (Haites, 2018).

The monitoring, reporting and verification (MRV) system in Vietnam doesn't have enough technical resources or infrastructure, which makes it hard to get accurate emissions data for a carbon tax (World Bank Group, 2022). Third, a clear legal framework is needed to figure out what things are taxable and what tax rates are fair. This should not conflict with carbon market rules like emission quota trading or forest carbon credits (Dung, Ngoc and Huy, 2024). Finally, the lack of awareness and capacity of law enforcement agencies at the local level can reduce the effectiveness of carbon tax implementations, especially in small and medium-sized industries or forest carbon credit projects (Nguyet, 2025).

Economic and social challenges

Economically, the application of a carbon tax can increase the production costs of heavy industries such as electricity, steel, and cement. These are industries that account for a large proportion of Vietnam's economy, so this will affect commodity prices and competitiveness in the international market, especially when products are exported to areas where CBAM is applied, such as the EU (Böhringer, Müller and Schneider, 2015). SMEs make up about 98% of all businesses in Vietnam. They often don't have the money or technology to follow the rules for carbon taxes or take part in carbon markets, which could mean they miss out on the global supply chain (Dung, Ngoc and Huy, 2024). A carbon tax makes things more expensive, like energy and consumer goods, which can make life harder for families with low incomes. This can lead to social pressure and the risk of public opposition if the right support measures are not in place (Bui, 2024). Also, not many people in business or the public know about the long-term benefits of carbon taxes and carbon markets, which makes it harder to support climate policies (Ngan,

2023). Vietnam needs to find a balance between its environmental goals and its socio-economic stability. It can learn from other countries, like the EU, which has put in place policies to help lessen the economic effects.

Opportunities from carbon taxes and carbon markets

Despite facing many challenges, carbon taxes and carbon markets offer many opportunities for Vietnam. First, carbon taxes generate significant budget revenues to reinvest in climate projects such as renewable energy, forest management, and green infrastructure, contributing to the realization of the Net Zero goal by 2050 (World Bank Group, 2022). Second, adding carbon taxes to the carbon market will make businesses more likely to invest in green technologies like solar, wind, and energy-efficient technologies. This will make the economy more competitive and bring in more foreign investment (Calel and Dechezleprêtre, 2016). Third, a good system for putting a price on carbon in Vietnam will help the country meet international standards. This will keep trade barriers from hurting export industries like steel and cement (European Commission, 2024). Fourth, carbon markets, especially forest carbon credits, create jobs in the area and get people to protect forests. This is what research on the forest carbon market in Vietnam (Dung, Ngoc and Huy, 2024). Finally, a carbon tax and carbon market will make Vietnam more trustworthy in international climate talks and help the country get money from groups like the World Bank (UNFCCC, 2022).

Recommendations on Policies and Legal Regulations in Vietnam

Develop a legal framework for carbon taxes

With the current limitations, the development of a legal framework to integrate carbon tax with the carbon market towards the proper implementation of international commitments on emission reduction and ensuring the sustainable development of the economy, Vietnam needs to pay attention to the following issues:

Principles of building an integrated legal framework

The creation of a comprehensive legal framework for carbon taxes and markets must adhere to essential principles to ensure both efficiency and feasibility. First, transparency requires regulations on carbon tax, quota allocation, and credit trading to be clear, public, and accessible, learning from the EU ETS's transparent MRV system (European Commission, 2023).

Second, equity ensures that local communities and small and medium-sized enterprises participating in forest carbon credit projects can join without facing disadvantages (Dung, Ngoc, and Huy, 2024). Third, the regulatory framework needs to make the cost of lowering emissions as low as possible using a "cap-and-trade" system and a carbon tax as a floor price, like what has been done in the EU and China (Cui *et al*., 2021). Fourth, compatibility ensures coordination between carbon taxes and carbon markets, avoiding overlap and enhancing emission reduction efficiency (Xu, Wang, and Zhang, 2023). Fifth, international integration requires the legal framework to meet international standards such as the Paris Agreement and the EU's CBAM, to support Vietnam's export

industries (Böhringer, Müller, and Schneider, 2015). Finally, sustainability emphasizes the use of carbon tax revenues and carbon markets to invest in renewable energy and forest protection, contributing to the goal of Net Zero by 2050 (Long Hong Bui, 2024).

Proposals for amendments and supplements to current laws

Vietnam needs to change and add to its laws in some ways so that carbon taxes and carbon markets can work together. The 2010 Environmental Protection Tax Law needs to be changed first. It needs to have rules about the carbon tax, make it clear which industries are taxable (like steel, cement, and electricity), and set tax rates based on how much CO2 they put out. The original carbon tax rate in China (6–9 USD/ton) should be used as a guide to help the economy (Li, Wang and Qin, 2025). Secondly, Decree 06/2022/ND-CP needs to be changed so that the rules for giving out emission quotas, holding auctions, and trading carbon credits are easier to understand. This is especially true for forest carbon credits. The EU ETS has a good example of how to do this based on energy efficiency and public auctions (Calel and Dechezleprêtre, 2016). Third, a circular needs to be sent out that explains how to collect, certify, and trade carbon credits, as well as how to set up a monitoring, reporting, and verification (MRV) system with consistent standards and independent verification. Fourth, we need to set up a national committee on carbon pricing with people from relevant ministries and sectors. This will help with coordination and policy implementation, and we can learn from China's experience with managing its national ETS (Cui *et al*., 2021). To meet international obligations like those in the Paris Agreement (UNFCCC, 2022), it is important to control how carbon tax and carbon market revenues are reinvested in climate projects like renewable energy and forest protection. .

Solutions to ensure the coordination between the carbon tax and the carbon market

The coordination of carbon taxes and carbon markets is a core factor in creating an effective carbon pricing system in Vietnam.

First, it is necessary to establish a carbon tax as a floor price to supplement the emission quota trading market, ensure a stable carbon price and encourage emission reduction, as has been implemented in the EU ETS (European Commission, 2023). Second, there needs to be a way for businesses to switch from carbon credits to carbon tax obligations. For example, businesses could use carbon credits from projects like protecting forests to lower their tax obligations. This is something that China has done in pilot programs (Dung, Ngoc and Huy, 2024). Third, the regulatory framework needs to make sure that the domestic carbon pricing system is strong enough to support export industries like steel and cement, which will help the EU's Carbon Border Adjustment Mechanism (CBAM) avoid border tariffs (Böhringer, Müller and Schneider, 2015). Fourth, we need to work with organizations like the World Bank to build a strong MRV system that will give us accurate emissions data for both carbon taxes and carbon markets. Fifth, businesses and the public need to get technical training and awareness-raising programs, based on what China has done, to get more people to support and take part in the carbon market (Li, Wang and Qin, 2025). Finally, there should be a national carbon exchange run by an independent group that handles carbon quota and credit trading. This will make sure that everything is clear and efficient (Transition Asia, 2025).

Strengthening law enforcement

Enforcement of carbon tax and carbon market laws in Vietnam faces many challenges such as: i) limited technical capacity of enforcement agencies, especially at the local level, making it difficult to monitor and verify emissions data, leading to the risk of fraud or false reporting from businesses (World Bank Group, 2022); ii) lack of synchronization between Carbon tax and carbon market regulations can be confusing in the enforcement process, such as the determination of liability between parties to carbon quota and credit transactions (Xu, Wang and Zhang, 2023); iii) SMEs often lack the financial and technical resources to comply with complex carbon pricing regulations leading to the risk of non-compliance or oppose the policy (Dung, Ngoc and Huy, 2024); iv) low public and business awareness of the benefits of carbon taxes and carbon markets that reduce cooperation in law enforcement (Nguyen, 2023) and v) pressure from international requirements such as the EU's Carbon Border Adjustment Mechanism (CBAM) requires Vietnam to quickly upgrade its enforcement capacity to meet international standards but this is difficult due to resource and time constraints (Böhringer, Müller and Schneider, 2015).

So, to make sure that carbon tax and carbon market laws are followed more strictly, Vietnam needs to put in place certain solutions: First, we need to spend money on training and building the skills of enforcement agencies, especially at the local level. This can be done through training programs on MRV systems and carbon market management, based on what we've learnt from the EU ETS. Second, the Ministry of Natural Resources and Environment needs to set up an independent verification agency to keep an eye on emissions data, make sure it is clear, and stop fraud (Calel and Dechezleprêtre, 2016). Third, detailed enforcement guidelines should be developed, including carbon tax compliance checks, quota trading, and carbon credit confirmation, in order to minimize confusion and increase consistency in law enforcement. Fourth, it is necessary to implement policies to support small and medium-sized enterprises, such as carbon tax exemption and reduction in the early stages, or provide technical assistance to enhance compliance and reduce economic pressures. Finally, it is necessary to step up communication campaigns to raise awareness among businesses and the public about the legal responsibilities and benefits of carbon pricing, learning from China's environmental education programs (Li, Wang and Qin, 2025).

Vietnam also needs to work with other countries to get more help with the implementation process. It is very important for countries to work together to help Vietnam's police deal with carbon pricing better. Vietnam should: i) work with international organizations like the World Bank and the United Nations Environment Programme (UNEP) to get help building a strong MRV system; ii) take part in international training programs on managing the carbon market and enforcing the carbon tax, like EU-organized courses to improve the skills of enforcement agencies; iii) learn from the experiences of pioneering countries like the EU and China on how to set up compliance inspection systems and deal with violation. These steps will help Vietnam better enforce its laws and improve its standing in the world's climate commitments.

Support businesses and communities

Propose supporting policies when integrating the carbon tax with the carbon market

Vietnam needs to put certain policies in place to help businesses and communities. First, we need to set up financial support programs. For example, small and medium-sized businesses could be exempt from the carbon tax for the first three to five years. We could also give them low-interest loans to invest in green technologies, based on what we learnt from the EU ETS support policies. Second, technical training programs on MRV systems and carbon credit project management need to be put in place, especially for small and medium-sized businesses and local communities that are working on projects to protect forests. This is based on what China learnt from its pilot programs (Cui *et al*., 2021). Third, we need to use money from carbon taxes and carbon markets to set up national climate funds that will pay for renewable energy projects and protect forests. This will help local communities directly. Finally, with the help of business associations and NGOs, we need to set up local business support centres that can give legal and technical advice. This will make sure that small and medium-sized businesses and local communities can fully access support resources.

Increase awareness and community participation

Increasing awareness and promoting business and community engagement are essential for the success of carbon taxes and carbon markets. First, there is a need to implement national communication campaigns, using channels such as television, social media, and local workshops, to explain the benefits of carbon pricing, such as improving the environment and creating economic opportunities from forest carbon credits (Li, Wang and Qin, 2025). Second, community training programs, especially in areas with high forest carbon credit potential, such as the Central Highlands and the Northwest, should be organized to guide local communities on how to participate in forest protection projects and carbon credit trading. Third, it is necessary to cooperate with NGOs and business associations to organize dialogue forums to help businesses and communities contribute their opinions to the process of developing carbon pricing policies. Fourth, it is necessary to build transparent online portals, provide information on carbon tax, carbon markets, and support and learning programs from EU information platforms. Finally, the participation of international organizations, such as the World Bank, should be encouraged to provide financial and technical support for awareness campaigns, in order to increase the support and participation of businesses and communities in the implementation of Viet Nam's climate goals.

Conclusion

To commit to taking a step toward achieving net-zero emissions by 2050 internationally and to better help protect and promote the competitiveness of the economy, Vietnam is in urgent need of developing a comprehensive legal framework to facilitate the goal of achieving efficient specialization, including the operation of a carbon tax and ETS. This is a complex legal-economic problem that requires an integrated policy solution where the two tools do not exclude but complement each other: where the carbon tax sets a floor price and generates the signals of certainty and long-term investment, and the

market of carbon ETS ensures efficient allocation of resources. Costing the implementation of emission reductions society-wide.

The success of this hermaphrodite model requires the establishment and operationalization of the three legal bottom lines. Enhancing the institution and legal foundation requires revising and supplementing existing legal documents, particularly the Law on Environmental Protection Tax from 2010. It is necessary to codify the carbon tax as an independent tax or a separate chapter with taxable objects, the calculation method, and tax rate schedule are clearly and scientifically regulated, with a gradual increase roadmap. At the same time, the compatibility and interconnection between tax regulations and ETS market regulations, which have been stipulated in quite basic content in the Law on Environmental Protection 2020 and guiding documents, form a unified institution. Second, guarantee the capacity and effectiveness of enforcement; a body of law, no matter how perfect, is always null and void without effective enforcement. Thus, the development of an MRV system, which is transparent, accurate, trustworthy, and reliable, and in line with international standards, is a critical need. MRV is not merely a technical tool but also a legal infrastructure for the monitoring and enforcement of tax liabilities, allocation of permits, and the punishment of non-compliance, and is crucial to ensure the combination of compliance and fairness for the system. Establishing a fair distribution and support mechanism is essential, as imposing environmental financial obligations will inevitably impact economic actors, particularly small and medium-sized enterprises (SMEs). Therefore, the law must anticipate targeted support mechanisms (such as tax exemptions and reductions for a limited time, technical support for technology transformation) and use the proceeds from carbon pricing to reinvest in green activities. This is not a blessing but a legal tool to ensure the principle of just transition, minimize social disturbances, and maintain political consensus.

In conclusion, proactively establishing a comprehensive legal framework for carbon pricing is a strategic step, not only helping Vietnam fulfill its international obligations but also an effective economic and legal tool to protect domestic production, enhance national sovereignty, and promote the process of restructuring the economy towards sustainability.

The integrated carbon pricing tools model proposed for Vietnam has a high reference value and transfer authority to other developing countries in Asia and even in the world on the basis of common legal-economic principles. This transfer is not a copy of the machines, but applies the leftover lessons creatively. First, the principle of phased implementation suggests that in jurisdictions where institutions are not yet established, it is prudent policy, as a legal matter, to implement the policy in stages. To go from the building of a legal foundation in the course of piloting to the expansion of coverage and tightening of obligations has given time to state organs and businesses to adjust themselves and have the relevant experience and capacity so as to reduce the shock of legality and economics. Vietnam's experience in creating instruments to support SMEs exemplifies the principle of special and differential treatment, highlighting its significance as one of the most salient principles in international law. Acknowledgment and laws for vulnerable stakeholders not only provide social justice, they keep intact the economic framework of the power structure that relies heavily on this sector across developing nations.

In light of the emerging trade barriers linked to environmental standards, such as the EU's Carbon Border Adjustment Mechanism, it is strategically essential for countries to proactively establish their carbon pricing systems to effectively realize trade remedies. It enables the country to preserve the revenues on carbon resources rather than pass them to other countries in the form of import duties and to show the congruence of its regulatory framework with international criteria. Finally, the principle of maximizing and legalizing national resource assets (for countries of high forest resource potential), Vietnam's example of constructing a forest carbon credit market, demonstrates the process of how a natural asset is transformed into an exchange-traded financial asset. It is also useful as a contribution to sustainable development and biodiversity conservation, and as a confirmation of the sovereignty over the country's resources. Therefore, while each country needs to adjust its policy parameters (tax rate, total quotas, and subjects to apply) according to their legal, economic, and political specific case, the principles drawn from Vietnam's model can be completely applied to develop effective and equitable carbon pricing systems throughout the world.

Acknowledgement

This article forms part of the Ministry-level Science and Technology Project of the Ministry of Education and Training of Vietnam in 2024, titled "Theoretical and practical basis for proposing the development of laws on carbon tax in Vietnam" (Project code: B2024-LPS-01).

References

Jaelani, A.K., Resti D.L., Muhammad J.H., Reza O.K. and Fitri N.A. (2024). Indonesia Carbon Tax Policy: A Key Role in Sustainable Development Goals. *AIP Conf. Proc.*, 3048: 020040. DOI: https://doi.org/10.1063/5.0202042.

Aldy, J.E. and Stavins, R.N. (2012). The Promise and Problems of Pricing Carbon: Theory and Experience. *Journal of Environment & Development*, 21(2): 152-180. DOI: https://doi.org/10.1177/1070496512442508.

Böhringer, C., Müller, A. and Schneider, J. (2015). Carbon Tariffs Revisited. *Journal of the Association of Environmental and Resource Economists*, 2(4): 629-672. DOI: https://doi.org/10.1086/683607.

Bui, L.H. (2024). Vietnam net-zero commitment: Opportunities, challenges and solutions. *Vietnam Journal of Agricultural Sciences*, 7(2): 2320. Available online at: https://vjol.info.vn/index.php/veae/article/view/103639 [accessed 22 June 2025].

Calel, R. and Dechezleprêtre, A. (2016). Environmental policy and directed technological change: Evidence from the European carbon market. *Review of Economics and Statistics*, 98(1): 173-191. DOI: https://doi.org/10.1162/REST_a_00470.

Cui, J., Xiao, J., Li, X. and Li, H. (2021). The effectiveness of China's regional carbon market pilots in reducing firm emissions. *Proceedings of the National Academy of Sciences*, 118(52): e2109912118. DOI: https://doi.org/10.1073/pnas.2109912118.

Dobrovolska, O., Günther, S., Chernetska, O., Dubrova, N. and Kachula, S. (2024). Environmentally related taxes and their influence on decarbonization of the economy. *Environmental Economics*, 15(1): 174-189. DOI: http://dx.doi.org/10.21511/ee.15(1).2024.13.

Dung, D.T., Ngoc, H.H. and Huy, H.N. (2024). Developing the Forest Carbon Credit Market in Vietnam: Current Situation and Policy Recommendations. *Vietnam Socio-Economic Development*, 29(2): 67-80. Available online at: https://tinyurl.com/24j8vkzn [accessed 22 June 2025].

Ellerman, A.D. and Buchner, B.K. (2007). The European Union Emissions Trading Scheme: Origins, allocation, and early results. *Review of Environmental Economics and Policy*, 1(1): 66-87. DOI: https://doi.org/10.1093/reep/rem003.

European Commission (2024). Report from the Commission to the Parliament and the Council on the functioning of the European carbon market in 2023. Available online at: https://tinyurl.com/4rsrbfdv [accessed 22 June 2025].

European Commission (2025). Carbon Border Adjustment Mechanism (CBAM). Available online at: https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en [accessed 22 June 2025].

Goulder, L.H. and Schein, A.R. (2013). Carbon taxes versus cap and trade: A critical review. *Climate Change Economics*, 4(3): 1350010. DOI: https://doi.org/10.3386/w19338.

Government of Vietnam (2020). Law on Environmental Protection 2020 (Law No. 72/2020/QH14). Available online at: https://vanban.chinhphu.vn/?pageid=27160&docid=202613 [accessed 22 June 2025].

Government of Vietnam (2022). Decree 06/2022/ND-CP: Regulations on greenhouse gas emission mitigation and ozone layer protection. Available online at: https://vanban.chinhphu.vn/?pageid=27160&docid=205039 [accessed 22 June 2025].

Green, J.F. (2021). Does carbon pricing reduce emissions? A review of ex-post analyses. *Environmental Research Letters*, 16(4). DOI: https://doi.org/10.1088/1748-9326/abdae9.

Gurtu, A., Vyas, V. and Gurtu, A. (2022). Emissions Reduction Policies and Their Effects on Economy. *Journal of Risk and Financial Management*, 15(9): 404. DOI: https://doi.org/10.3390/jrfm15090404.

Haites, E. (2018). Carbon taxes and greenhouse gas emissions trading systems: What have we learned? *Climate Policy*, 18(8): 955-966. DOI: https://doi.org/10.1142/S2010007813500103.

IPCC (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. In: H.O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.). Cambridge: Cambridge University Press. Available online at: https://www.ipcc.ch/report/ar6/wg2/ [accessed 22 June 2025].

Ikhtiari, K., Nurfadila, N. and Ibrahim, F.N. (2024). The Influence of Carbon Tax on Green Economy: A Literature Analysis. *Advances in Taxation Research*, 2(2): 109-119. DOI: https://doi.org/10.60079/atr.v2i2.295.

Kovalenko, V., Kolb, O., Bondarenko, O., Boldizhar, S. and Marko, S. (2023). Exploring the legal dimensions of environmental policy within the framework of Ukraine's sustainable development strategy. *Grassroots Journal of Natural Resources*, 6(3): 46-66. DOI: https://doi.org/10.33002/nr2581.6853.060304.

Li, Y., Wang, X. and Qin, Q. (2025). Comparative analysis of carbon tax and carbon market strategies for facilitating carbon neutrality in China's coal-fired electricity sector. *Sustainability*, 17(5): 1961. DOI: https://doi.org/10.3390/su17051961.

National Assembly of Vietnam. (2020). Law No. 72/2020/QH14 of the National Assembly Vietnam's Environmental Tax Law. Available online at: https://vanban.chinhphu.vn/?pageid=27160&docid=202613 [accessed 22 June 2025].

Nguyen, M.A. (2023). Implication of Vietnam's Environmental Tax Law in the green economy transition process. *Green Policy Network*. Available online at: https://tinyurl.com/y4vsaw4n [accessed 22 June 2025].

Ngan, T.K.N. (2023). Inadequacies from Vietnam's environmental tax policy, *Economics and Forecasting*. Available online at: https://tinyurl.com/uphsmc3a [accessed 22 June 2025].

Nguyet, T.N. (2025). Challenges in applying carbon tax in Vietnam and solutions to overcome it. *State Management*. Available online at: https://tinyurl.com/5kr2eyjp [accessed 22 June 2025].

OECD (2021). *Effective carbon rates 2021: Pricing carbon emissions through taxes and emissions trading*. Paris: OECD Publishing. DOI: https://doi.org/10.1787/0e8e24f5-en.

O'Mahony, T. (2020). State of the art in carbon taxes: a review of the global conclusions. *Green Finance*, 2(4): 409-423. DOI: https://doi.org/10.3934/GF.2020022.

Quan, Y. and Duan, M. (2023). Emission reductions, industrial competitiveness, and spillover effects under China's regional emission trading systems: Evidence from the iron and steel sector. *Journal of Environmental Management*, 344: 118481. DOI: https://doi.org/10.1016/j.jenvman.2023.118481.

Ramadhani, D.P. and Koo, Y. (2022). Comparative Analysis of Carbon Border Tax Adjustment and Domestic Carbon Tax under General Equilibrium Model: Focusing on the Indonesian Economy. *Journal of Cleaner Production*, 377: 134288. DOI: https://doi.org/10.1016/j.jclepro.2022.134288.

Salma, A., Fryda, L. and Djelal, H. (2024). Biochar: A Key Player in Carbon Credits and Climate Mitigation. *Resources*, 13(2): 31. DOI: https://doi.org/10.3390/resources13020031.

Santos, G. (2022). Climate change policy and carbon pricing. *Energy Policy*, 168: 112985. DOI: https://doi.org/10.1016/j.enpol.2022.112985.

Shob, R. and Joshi, R. (2022). Impact of Variation in Monsoonal Rainfall and Temperature on Paddy Production and its Adaptive Strategies: A Case Study from Bhaktapur District of Nepal. *Grassroots Journal of Natural Resources*, 5(4): 99-118. DOI: https://doi.org/10.33002/nr2581.6853.050406.

Sorensen, D. (2023). Tokenized Carbon Credits. *Ledger*, 8: 76-91. DOI: https://doi.org/10.5195/ledger.2023.294.

Thisted, E.V. and Thisted, RV. (2019). The diffusion of carbon taxes and emission trading schemes: the emerging norm of carbon pricing. *Environmental Politics*, 29(5): 804-824. DOI: https://doi.org/10.1080/09644016.2019.1661155.

Timilsina, G.R. (2022). Carbon Taxes. *Journal of Economic Literature*, 60(4): 1456-1502. DOI: https://doi.org/10.1257/jel.20211560.

Transition Asia (2025). Steel enters China's national emissions trading scheme, 27 March. Available online at: https://transitionasia.org/steel-enters-chinas-national-emissions-trading-scheme/ [accessed 22 June 2025].

Tsai, W.H. (2020). Carbon Emission Reduction—Carbon Tax, Carbon Trading, and Carbon Offset. *Energies*, 13(22): 6128. DOI: https://doi.org/10.3390/en1322612.

UNFCCC (2022). Vietnam's updated Nationally Determined Contribution (NDC). Available online at: https://unfccc.int/sites/default/files/NDC/2022-11/Viet%20Nam_NDC_2022_Eng.pdf [accessed 22 June 2025].

World Bank Group (2022). Vietnam country climate and development report, CCDR Series. Available online at: http://hdl.handle.net/10986/37618 [accessed 22 June 2025].

Xu, H., Wang, X. and Zhang, X. (2023). Comparing the impacts of carbon tax and carbon emission trading, which regulation is more effective? *Journal of Environmental Management*, 330: 117156. DOI: https://doi.org/10.1016/j.jenvman.2022.117156.

Zhang, D., Zhang, H., Wang, Q. and Su, B. (2014). Emissions trading in China: Progress and prospects. *Energy Policy*, 75: 9-16. DOI: https://doi.org/10.1016/j.enpol.2014.01.022.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*
Conceived and designed the research or analysis	Yes	No	Yes
Collected the data	No	No	Yes
Contributed to data analysis and interpretation	Yes	Yes	No
Wrote the article/paper	Yes	Yes	No
Critical revision of the article/paper	No	Yes	No
Editing of the article/paper	No	Yes	Yes
Supervision	No	No	Yes
Project Administration	Yes	No	Yes
Funding Acquisition	No	No	No
Overall Contribution Proportion (%)	40	30	30

Funding
This article forms part of the Ministry-level Science and Technology Project of the Ministry of Education and Training of Vietnam in 2024 titled "Theoretical and practical basis for proposing the development of laws on carbon tax in Vietnam" (Project code: B2024-LPS-01).

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